Direct In-Gel Fluorescence Detection and Cellular Imaging of *O*-GlcNAc-Modified Proteins

- Supporting Information -

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General Reagents and Methods:

Unless otherwise noted, reagents were purchased from the commercial suppliers Fisher (Fairlawn, NJ) or Sigma-Aldrich (St. Louis, MO). Protease inhibitors were purchased from Roche Applied Sciences (Indianapolis, IN), sequencing grade trypsin was from Promega (Madison, WI), agarose-conjugated protein G was from Pierce (Rockford, IL), and Immobilon-FL PDVF membrane was from Millipore (Billerica, MA). Dulbecco's modified Eagle media (DMEM), B27, fetal bovine serum (FBS) and penicillin/ streptomycin were from Gibco (Carlsbad, CA). The anti-α-crystallin (ab5595) and anti-β-tubulin antibodies were from Abcam and Sigma, respectively. Click-It™ *O*-GlcNAc Enzymatic Labeling System, Click-It™ Biotin Glycoprotein Detection Kit, Click-It™ Tetramethylrhodamine (TAMRA) Glycoprotein Detection Kit, anti-TAMRA antibody, 4-12% NuPAGE® Bis-Tris Mini gels, pH 4-7 Zoom IPG strips, and lithium dodecyl sulfate (LDS) buffer were from Invitrogen (Carlsbad, CA). Peptide N-glycosidase F (PNGase F) was purchased from New England Biolabs (Beverly, MA). The anti-*O*-GlcNAc antibodies CTD110.6 and RL-2 were from Covance (Princeton, NJ) and Affinity Bioreagents (Golden, CO), respectively. Wheat germ agglutinin (WGA) lectin was from EY laboratories (San Mateo, CA). The secondary goat anti-rabbit antibody conjugated to IRDye800 was from Rockland Immunochemicals (Gilbertsville, PA), and the streptavidin-IR680 conjugate was from Li-COR Biosciences (Lincoln, NE). Sprague-Dawley and Long Evans rats were from Charles River Laboratories (Wilmington, MA). All protein concentrations were measured using the BCA protein assay (Pierce). Western blots were visualized and quantified using an Odyssey infrared imaging system (LI-COR Biosciences). In-gel fluorescence detection was performed using a FujiFilm FLA-3000 or FLA-5100 scanner, and the fluorescence was displayed in green pseudocolor.

Chemoenzymatic Labeling of α-Crystallin. α-Crystallin from the Click-It™ *O*-GlcNAc Enzymatic Labeling System (20 μg) was labeled with UDP-GalNAz **1** and biotin alkyne **2** as per the Click-It™ *O*-GlcNAc Enzymatic Labeling System and Click-It™ Biotin Glycoprotein Detection Kit instructions. Negative controls were performed under identical conditions, except GalT, **1**, or **2** were left out of the reactions. α-Crystallin (10 pmol from each reaction) was resolved on a 1.5 mm, 10-well NuPAGE 4-12% Bis-Tris gel and transferred to PDVF. The membrane was blocked with 5% BSA in 50 mM Tris-HCl pH 7.4, 150 mM NaCl containing 0.1% Tween (TBST) for 1 h at RT followed by 1

h incubation with a streptavidin-IR680 conjugate (1:10,000) in TBST. After four washes for 15 min in TBST, the membrane was visualized using an Odyssey imaging system. The same membrane was then blotted with an anti-α-crystallin antibody (1:1000) in 5% nonfat milk / TBST for 1 h at RT. Following three washes in TBST for 5 min, the membrane was incubated with a goat anti-rabbit antibody conjugated to IRDye800 (1:10,000) in the same buffer for 1 h at RT, washed three more times for 10 min, and then visualized using an Odyssey imaging system. To examine the detection sensitivity, 25, 10, 5, 1, 0.5, and 0.25 pmol of labeled α-crystallin were resolved by SDS-PAGE, transferred to PDVF, and immunoblotted with a streptavidin-IR680 conjugate (1:10,000). For comparison, unlabeled α-crystallin (25 pmol) was resolved by SDS-PAGE, transferred to PDVF, and immunoblotted with the CTD110.6 antibody (1:1000), RL-2 antibody (1:1000), or WGA lectin (10 μg/mL) for 1 h at RT.

Chemoenzymatic Labeling of Rat Forebrain Extracts. The forebrains from three adult rats (~150 g, male Sprague Dawley) were extracted and fractionated using the Qproteome Cell Compartment Kit (Qiagen). Fractions 1 (the cytoplasmic fraction) and 3 (the nuclear fraction) were precipitated with 4 volumes ice-cold acetone followed by overnight incubation at -20 ºC and redissolved in 2% SDS plus Complete™ protease inhibitors. Protein from each fraction (1.5 mg for the 2D gel labeling, 0.5 mg for the 1D gel labeling) was precipitated and labeled at 1 mg/mL as per the Click-It™ *O*-GlcNAc Enzymatic Labeling System instructions, except that Complete™ protease inhibitors were added during the labeling reaction. Briefly, precipitated samples were dissolved to 5 mg/mL in 1% SDS, 20 mM HEPES, pH 7.9 and diluted 5-fold into a buffer with the following final concentrations: 20 mM HEPES, pH 7.9, 50 mM NaCl, 2% NP-40, 5.5 mM $MnCl_2$. UDP-GalNAz **1** (25 μM), and GalT (25 ng/μL) were added, and the samples were incubated at 4 °C for 14-20 h. The samples were subsequently labeled with the TAMRA-alkyne dye **3** as per the Click-It™ TAMRA Glycoprotein Detection Kit instructions, except that EDTA-free Complete™ protease inhibitors were added during the TAMRA labeling reaction. For the 1D gels, negative controls were performed under identical conditions for each fraction except that GalT was omitted from the labeling reaction.

Immunoprecipitation of TAMRA-Labeled *O*-GlcNAc Proteins. Labeled samples were precipitated using methanol/chloroform/water, brought up to a concentration of 2 mg/mL in 1% SDS plus Complete™ protease inhibitors, and boiled. The SDS was then quenched with 1 volume of NETFD buffer (100 mM NaCl, 50 mM Tris-HCl pH 7.4, 5 mM EDTA, 6% NP-40) plus protease inhibitors, and the lysate was precleared against washed protein G sepharose beads (1 mL/1.5 mg of protein) at 4 ºC for 1 h. After centrifugation, the supernatant was collected and incubated with an anti-TAMRA antibody (100 μg/1.5 mg of protein) at 4 ºC for 4 h. The samples were then added to pre-washed protein G sepharose beads (1 mL/1.5 mg of protein) at 4 ºC for 1.5 h. Following centrifugation, the beads were washed once with 4 column volumes of NETFD buffer and three times with 4 column volumes of NETF buffer (100 mM NaCl, 50 mM Tris-HCl pH 7.4, 5 mM

EDTA). After washing, the beads were boiled in elution buffer (200 mM Tris pH 6.8, 400 mM DTT, 8% SDS, 50 μL buffer/100 μL beads). The supernatant was collected after centrifugation and precipitated by adding 4 volumes of ice-cold acetone and incubating at -20 ºC for 16 h.

1D Gel Electrophoresis and Silver Staining. The precipitated eluents (cytoplasmic, nuclear, and –GalT controls) from above, along with the input (before immunoprecipitation) and flow-through fractions (15 μg) were separated on a 1.5 mm, 10-well NuPAGE 4-12% Bis-Tris gel. The gels were imaged using a FujiFilm FLA-3000 or FLA-5100 scanner and silver stained using a protocol adapted from Blum, Shevchenko and co-workers.[1] Briefly, the gels were fixed in an aqueous solution of 50% MeOH, 10% acetic acid for 30 min and then again in 5% MeOH, 1% acetic acid for 15 min. The gels were then washed 3 x 10 min with H_2O and sensitized for 90 s with $Na_2S_2O_3 \cdot 5H_2O$ (20 mg/100 mL). After rinsing for 3 x 30 sec with H_2O, the gels were exposed to $AgNO_3$ (200 mg/100 mL) for 30 min and rinsed for 3 x 60 s with H_2O. Finally, the gels were developed for 2.5 min in a solution containing Na_2CO_3 (6 g/100 mL), 37% formaldehyde (50 μL/100 mL), $Na_2S_2O_3 \cdot 5H_2O$ (0.4 mg/100 mL). The reaction was stopped with 6% acetic acid. Twelve equally-spaced gel pieces were excised from each of the eluent lanes (cytoplasmic, nuclear, and –GalT controls), spanning the full height of the gel. Individual gel pieces were destained in a solution containing 0.4 g $K_3Fe(CN)_6$ in 200 mL of an aqueous sodium thiosulphate solution (0.2 g $Na_2S_2O_3 \cdot 5H_2O$ in 1L of H_2O) for 15 min, and washed 4 times for 15 min and 1 time for 16 h with H_2O.

2D Gel Electrophoresis. Precipitated eluents (cytoplasmic, nuclear) were resuspended in 100 mM Tris, pH 8.0, 1% SDS, and then reduced and alkylated with tributyl phosphine (200 mM) and *N,N*-Dimethylacrylamide (0.5%) by heating at 65 °C for 10 min, followed by rotation end-over-end at RT for 20 min. The samples were precipitated with methanol/chloroform/water and resuspended in 7 M urea, 2 M thiourea, 2% CHAPS, 2% ASB-14 (Sigma) buffer (173.5 μL), and 2 M DTT (5.5 μL) plus pH 4-7 ampholytes (1 μL) were added. The samples were centrifuged at 20,000 rpm for 3 min, the supernatant was loaded onto pH 4-7 strips, and the sample was rehydrated for 90 min. The strips were focused for 20 min at 200V, 25 min at 450V, 20 min at 700V, and 55 min at 2000V, after which they were incubated in 1x LDS sample buffer plus 50 mM DTT, and resolved on a NuPAGE 4-12% Bis-Tris gel. The gel was imaged using a fluorescence scanner, and the fluorescent spots were excised from the gel and fixed in an aqueous solution of 50% MeOH, 7% acetic acid overnight.

In-Gel Digestion of Captured *O*-GlcNAc Proteins. Individual gel pieces (cytoplasmic, nuclear, and –GalT controls) from the 1D and 2D gels were dehydrated with CH_3CN (2 x 5 min) and then rehydrated with dithiothreitol (1.5 mg/mL in 100 mM NH_4HCO_3, pH 8.0) for 30 min. The excess dithiothreitol was removed and iodoacetamide (10 mg/mL in 100 mM NH_4HCO_3, pH 8.0) was added in the dark for 30 min. Excess iodoacetamide was removed and the gels were washed twice with 100 mM NH_4HCO_3, pH 8.0 and dried

with CH_3CN before being dried using a speed vac. Trypsin (20 ng/μL in 50 mM NH_4HCO_3, pH 8.0; 50 μL) was added to each gel piece, and the gel pieces were allowed to swell on ice. After 30 min, excess trypsin was removed, 50 mM NH_4HCO_3, pH 8.0 (15 μL for the 2D gel pieces; 30 μL for the 1D gel pieces) was added, and the digestions were incubated at 37 ºC. After 16 h, the peptides were extracted with H_2O (30 μL for the 2D gel pieces; 60 μL for the 1D gel pieces) for 30 min, and the gel pieces were washed twiced with an aqueous solution of 5% formic acid containing 50% CH_3CN (25 μL for the 2D gel pieces; 40 μL for the 1D gel pieces) for 10 min. The combined extract and washes were concentrated using a speed vac for 1 h to remove the CH_3CN.

LC-MS Analysis of Captured *O*-GlcNAc Proteins. Nano LC-MS of in-gel tryptic digests was performed on a Thermo Fisher Surveyor MS plus HPLC and LTQ XL ion trap mass spectrometer using a modified vented column setup and data dependent scanning.[2] Samples were loaded onto a 360 x 100 μm precolumn (2 cm, 5 μm Monitor C18) and desalted prior to placing the precolumn in-line with the analytical column. Peptides were then eluted with a linear gradient of 0% to 40% B in 30 min (A, 0.1M aqueous HOAc; B, 0.1M HOAc in CH_3CN), a flow rate of 250 nL/min and using a 360 x 75 μm self-packed column with integrated electrospray emitter (10 cm of 5 μm Monitor, C18). MS scans were as follows: 1 full scan followed by 5 MS/MS scans of the most intense ions from the full scan using data-dependent analysis with dynamic exclusion. Dynamic exclusion parameters: repeat count - 1; repeat duration – 15s; exclusion duration – 30s.

MS/MS spectra were searched against a human, rat and mouse subset of the European Bioinformatics Institute – International Protein Index (EBI-IPI) database (downloaded 08-01-2007), with an appended reversed database and using Sequest 3.0. A fixed modification of Cys (+57), a variable modification of Met (+16) and trypsin cleavage were specified. Search results were compiled and filtered in Scaffold 2.0 (Proteome Software, Inc, Portland, OR). For analysis of 2D gel bands, a protein identification was accepted if it was established with a 99% probability of a correct identification and a minimum of 2 peptides (90% probability of a correct identification) were matched to the protein. For analysis of 1D gel bands, a protein identification was accepted if a minimum of 3 peptides were matched to the protein and peptide identifications satisfied XCorr versus m/z thresholds of +1/1.8, +2/2.5, and +3/3.5, and a DeltaCn threshold of 0.1. Proteins published as putative *O*-GlcNAc proteins were chosen by taking the list of proteins identified in the experimental eluent lane and subtracting out those proteins found in the corresponding –GalT control lane, as well as any extracellular or transmembrane proteins that contaminated the protein fractions.

In-Gel Fluorescence Detection of *O*-GlcNAc Dynamics. HeLa cells were grown to 80-90% confluence in DMEM containing 10% FBS and penicillin/streptomycin (100 U/mL) and harvested. Cells were incubated in DMEM with PUGNAc (100 μM) or H_2O as a control for 9 h at 37 °C and 5% CO_2. The cells were lysed in boiling 1% SDS, sonicated, and boiled for 5 min. The resulting lysate (200 μg) was chemoenzymatically labeled with **1**, followed by **3**, as described above. A negative control was performed under identical conditions, except that **1** was omitted from the reaction mixture. After

TAMRA-labeling, protein (21 μg) was resolved on a 1.0 mm, 12-well NuPAGE 4-12% Bis-Tris Gel. The gel was imaged using a FLA-5100 scanner. Western blotting was done as described for α-crystallin above but using an anti-tubulin antibody (1:10,000).

Total changes in *O*-GlcNAc glycosylation levels upon PUGNAc treatment were quantified using Multi Gauge software (Fujifilm). Quantification was determined by taking the ratio of the total fluorescent signal of the PUGNAc lane to the total fluorescent signal of the control lane, corrected to tubulin levels. Quantification represents the mean ± standard deviation for two experiments. The range over which PUGNAc changed *O*-GlcNAc glycosylation levels was determined by taking the ratio of the fluorescent signal of the PUGNAc lane to the fluorescent signal of the control lane for the 18 strongest bands, corrected for tubulin levels.

Chemoenzymatic Labeling and Fluorescence Imaging of *O*-GlcNAc Proteins in Cells. HeLa cells were counted, diluted into DMEM containing 10% FBS and penicillin/streptomycin (100 U/mL) and seeded on poly-D-lysine-coated (0.1 mg/mL poly-D-lysine in 50 mM sodium borate, pH 10, 100 μL/coverslip for 30 min at 37 °C) 15-mm glass coverslips (Carolina Biologicals) at a density of 75 cells/mm^2 (100 μL/coverslip). After 30 min, 400 μL of media was added to each coverslip, and the cultures were incubated at 5% CO_2 at 37 °C for 6 h.

Cortical neuronal cultures were prepared from embryonic day 18 Long Evans rats as described.[3] Neurons were counted, diluted into supplemented Basal Media Eagle (BME, Sigma; 450 mL media, 10 mL L-glutamine (200 mM), 5 mL penicillin/streptomycin (10,000 U/mL), 10 mL B-27 serum-free supplement (50X stock), 25 mL FBS) and seeded on poly-DL-ornithine-coated 18-mm glass coverslips (Carolina Biologicals) at a density of 100 cells/mm^2 (150 μL/coverslip). After 30 min, 350 μL of supplemented BME media was added to each coverslip. The cultures were incubated in 5% CO_2 at 37 °C for 7 days.

To image *O*-GlcNAc glycosylated proteins, the media was removed, and the coverslips were rinsed one time with PBS, fixed in 4% paraformaldehyde for 20 min at RT, washed twice with PBS, permeabilized in 0.3% Triton X-100 for 5 min at RT, and washed twice with enzymatic labeling buffer (50 mM HEPES, 125 mM NaCl, pH 7.9). Reaction mixtures and negative controls without UDP-GalNAz **1** were prepared as described in the Click-It™ *O*-GlcNAc Enzymatic Labeling System instructions except that Component C, the enzymatic labeling buffer, was replaced with a buffer containing 125 mM NaCl, 50 mM HEPES, pH 7.9. These mixtures were added to each coverslip (50 μL), and the coverslips were incubated at 4 °C for 14-20 h. For the HeLa cells, PNGase F (2500 U/mL) was added to the enzymatic labeling reaction mixture; no difference in staining was observed in the presence or absence of PNGaseF. Coverslips were washed one time with 125 mM NaCl, 50 mM HEPES, pH 7.9 and twice with 50 mM Tris, pH 8.0. Biotin labeling reaction mixtures were prepared as per the Click-It™ Biotin Glycoprotein Detection Kit instructions using 50 mM Tris, pH 8.0 without SDS, added to each coverslip (50 μL), and the reaction allowed to proceed for 1 h at RT. For TAMRA labeling, TAMRA-alkyne **3** was substituted above for biotin-alkyne **2**. The TAMRA-alkyne **3** produced high background labeling in the absence of GalT that is most likely due to non-covalent association of the dye with hydrophobic regions of cell membranes and proteins. Consistent with this notion, washing the cells with organic

solvents such as methanol and DMSO reduced the background labeling but had detrimental effects on the cells. We did not observe a similar background when labeling cell lysates because the proteins were precipitated with chloroform, methanol and water, and the pellet was washed with methanol.

After the reaction was finished, the coverslips were washed once with PBS, three times with 0.1% Triton-X100 in PBS, and once with PBS. Following the PBS wash, non-specific binding was blocked by incubating with 3% BSA in PBS for 1 h at RT and then rinsing once with PBS. Cells were then incubated with streptavidin-AlexaFluor 488 (1:800; Molecular Probes) in 3% BSA in PBS for 1 h at 37 °C. Coverslips were rinsed three times with 0.2% Triton-X100 in PBS and once with PBS. The coverslips were mounted onto glass slides using Vectashield mounting medium with DAPI (2 μL; Vector Labs) and sealed with clear nail polish. Cells were imaged using a Nikon Eclipse TE2000-S inverted microscope, and images were captured with Metamorph software using a 40x plan fluor oil objective.

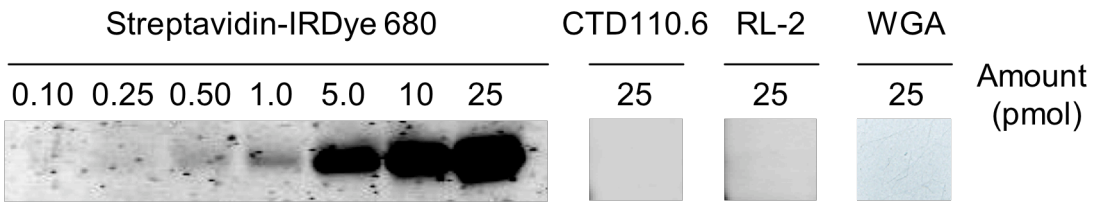

Figure S1. Detection sensitivity of the chemoenzymatic approach. α-Crystallin was biotin labeled, and the indicated amounts of the protein were resolved by SDS-PAGE, transferred to PVDF, and immunoblotted with a streptavidin-IRDye 680. As little as 250 fmol of α-crystallin (~25 fmol of glycosylated protein) was detected. In contrast, WGA lectin and the *O*-GlcNAc antibodies CTD110.6 and RL-2 failed to detect glycosylated α-crystallin.

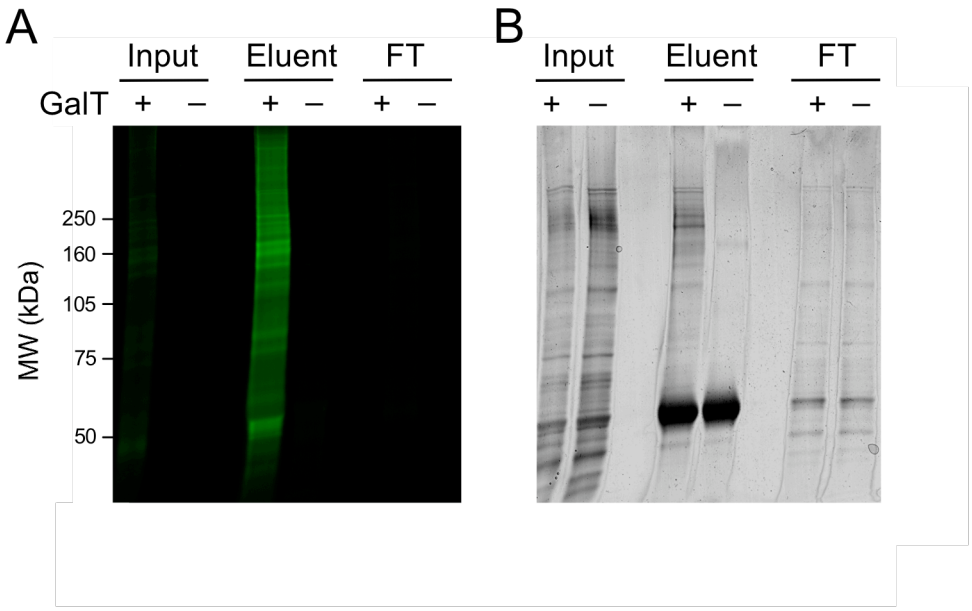

Figure S2. (A) Enrichment and in-gel fluorescence detection of *O*-GlcNAc modified proteins. *O*-GlcNAc proteins from the cytosolic fraction of adult rat forebrain were chemoenzymatically labeled with the TAMRA dye, immunoprecipitated with an anti-TAMRA antibody, and imaged using a fluorescence scanner. Input, lysate before immunoprecipitation (IP); Eluent, immunoprecipitated protein; FT, flow-through from the IP. (B) Silver stain of the corresponding fractions.

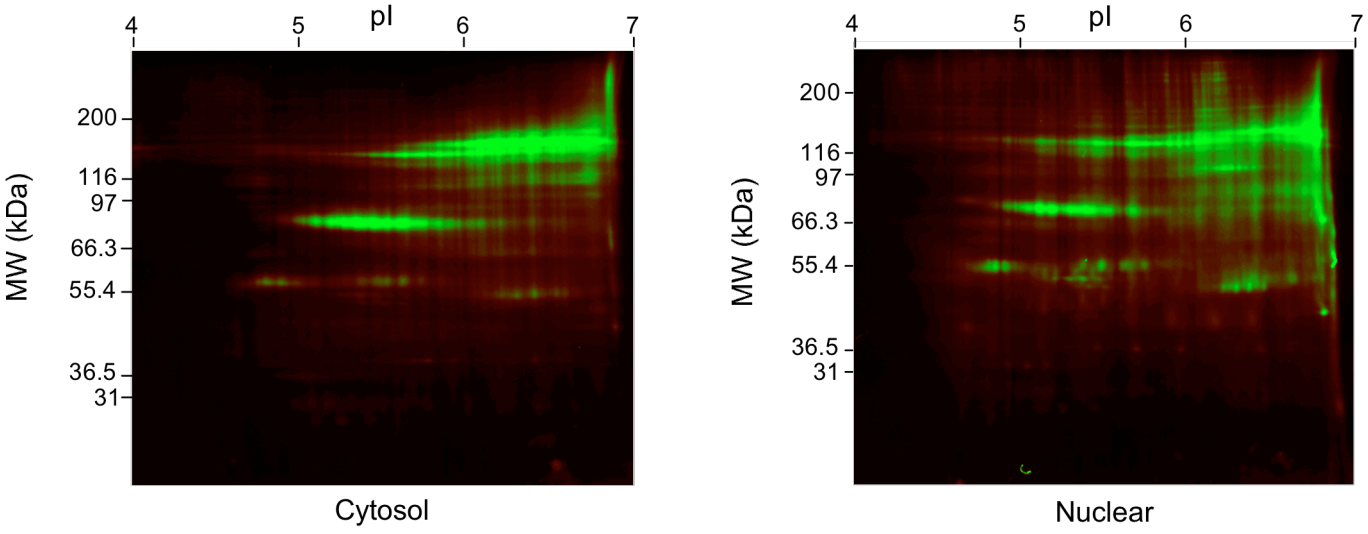

Figure S3. 2D gel electrophoresis of *O*-GlcNAc proteins from the cytosolic and nuclear fractions of adult rat forebrain. Proteins were chemoenzymatically labeled with the TAMRA dye, immunoprecipitated with an anti-TAMRA antibody, resolved by 2D gel electrophoresis, and imaged using a fluorescence scanner. Fluorescent spots were excised and the proteins identified by mass spectrometry.

***Table S1. O*-GlcNAc Glycosylated Proteins Identified by Mass Spectrometry.** Proteins are tabulated by function, and the accession number and number of peptides (# Pep.) found for that protein are listed. Previously identified *O*-GlcNAc proteins are indicated. † represents proteins that have been previously identified as *O*-GlcNAc proteins by any method. †† represents proteins that have been previously validated to contain *O*-GlcNAc either by direct identification of the *O*-GlcNAc modification by mass spectrometry or by radioactive GalT labeling.

Protein	Accession Number	# Pep.	Known
Cell Organization / Dynamics			
ACTA2 Actin alpha-2 chain	IPI00008603.1, IPI00021428.1, IPI00023006.1, IPI00025416.3, IPI00110827.1	8	†
ACTB Actin beta chain	IPI00021439.1, IPI00021440.1, IPI00848058.1	27	†
Ank2 Similar to Ankyrin 2 isoform 1	IPI00554111.2	10	
Ank3 Ankyrin 3	IPI00199445.2	19	††
ANXA2 Annexin A2	IPI00797556.1, IPI00848164.1	3	
Anxa6 Annexin A6	IPI00421888.3, IPI00831745.1	7	
ARPC2 Actin-related protein 2/3 complex subunit 2	IPI00005161.3, IPI00661414.2, IPI00764535.2	3	
CAPZB Isoform 1 of F-actin capping protein subunit beta	IPI00026185.5, IPI00191444.3, IPI00218782.2, IPI00269481.7, IPI00365283.1, IPI00406800.4, IPI00474883.2, IPI00642256.1, IPI00776140.1	8	††
Ckap5 Cytoskeleton associated protein 5	IPI00317134.3, IPI00337930.4, IPI00764313.1, IPI00764540.1, IPI00767392.1, IPI00769262.1	4	
Crym Mu-crystallin homolog	IPI00214448.1	14	
Cyln2 CAP-Gly domain-containing linker protein 2	IPI00195929.1	5	
Dnm1 Isoform 1 of Dynamin-1	IPI00272878.6, IPI00331293.3, IPI00413140.3, IPI00657691.2, IPI00816287.2	18	
Dync1h1 Dynein heavy chain, cytosolic	IPI00327630.1	29	†
Epb4.1l1 Isoform S of Band 4.1-like protein 1	IPI00203237.2, IPI00203239.2, IPI00561718.1	19	
Epb4.1l3 Type II brain 4.1 minor isoform	IPI00204503.1, IPI00204506.1, IPI00556956.2, IPI00558692.1, IPI00561669.1, IPI00568756.1	14	†
Fscn1 Fascin	IPI00353563.4, IPI00763106.1, IPI00767873.1	13	†
Ina Alpha-internexin	IPI00135965.2, IPI00211936.2, IPI00848753.1	6	†
LOC367171 Microtubule-associated protein 4 isoform 1	IPI00421342.2	15	††
Map1b similar to Microtubule-associated protein 1B	IPI00372009.3	13	††
Mtap1a Microtubule-associated protein 1A	IPI00199693.2	14	
Mtap2 Isoform MAP2x of Microtubule-associated protein 2	IPI00206171.1, IPI00231051.1, IPI00328017.4	42	††
Mtap6 STOP protein	IPI00210119.1, IPI00734617.2	14	
Myh10 Myosin, heavy polypeptide 10	IPI00338604.4, IPI00391300.3, IPI00397526.2, IPI00479307.3, IPI00515398.1, IPI00757312.1, IPI00790503.2	4	
Myo5a Myosin-Va	IPI00118120.1, IPI00214038.1, IPI00390377.2, IPI00776221.1	5	†
NCKAP1 Nck-associated protein 1	IPI00031982.1, IPI00214442.2, IPI00319320.4, IPI00409684.2, IPI00656204.1, IPI00755241.1, IPI00766452.1	7	
Rad23b UV excision repair protein RAD23 homolog B	IPI00008223.3, IPI00108774.1, IPI00210495.1	23	††
RP1-14N1.3 Ifapsoriasin	IPI00397801.4, IPI00787398.1	3	
Snip SNAP25-interacting protein	IPI00190619.3	9	
Spna2 Spectrin alpha chain, brain	IPI00209258.4	4	
Spnb2 Isoform 1 of Spectrin beta chain, brain 1	IPI00319830.7, IPI00555287.2	51	††

SPTAN1 Spectrin alpha, non-erythrocytic 1	IPI00478292.3, IPI00744706.1, IPI00745092.1, IPI00843765.1, IPI00844215.1	3	
TUBA4A Tubulin alpha-4A chain	IPI00007750.1, IPI00794663.1	18	††
TUBB Tubulin beta chain	IPI00011654.2	16	†
TUBB2A Tubulin beta-2A chain	IPI00013475.1	26	†
TUBB2B Tubulin beta-2B chain	IPI00031370.3	155	
TUBB2C Tubulin beta-2C chain	IPI00007752.1	65	†
TUBB3 Tubulin beta-3 chain	IPI00013683.2	10	
TUBB4 Tubulin beta-4 chain	IPI00023598.2	42	†
Wasf1 WAS protein family member 1	IPI00022007.1, IPI00213598.1, IPI00471372.2	6	
Wdr1_predicted WD repeat protein 1	IPI00215349.5	8	
Cellular Communication / Signal Transduction			
Amph1 Amphiphysin	IPI00196508.1	3	
Ap2a1 Isoform A of AP-2 complex subunit alpha-1	IPI00108780.6, IPI00203346.4, IPI00567919.2, IPI00622911.1, IPI00764057.1, IPI00765430.1, IPI00778656.1	10	††
Ap2a2 AP-2 complex subunit alpha-2	IPI00310131.5, IPI00471901.3, IPI00753468.1	8	
Ap2b1 Isoform 1 of AP-2 complex subunit beta-1	IPI00119689.1, IPI00220991.2, IPI00231502.3, IPI00333383.2, IPI00378063.1, IPI00389753.1, IPI00784156.1, IPI00784366.1, IPI00790702.1	6	
Ap3b2_predicted Similar to Adaptor-related protein complex 3 beta 2 subunit	IPI00368200.2	6	††
Bsn Protein bassoon	IPI00212553.3, IPI00556925.1	98	††
Cadps Calcium-dependent secretion activator 1	IPI00199577.5, IPI00199604.4, IPI00297412.4, IPI00330163.3, IPI00374128.3, IPI00384808.2, IPI00478178.4, IPI00668903.1, IPI00670114.1, IPI00747400.1	13	
CAMK2A Isoform A of Calcium/calmodulin-dependent protein kinase type II alpha chain	IPI00215715.3, IPI00550056.1	51	
Camkv CaM kinase-like vesicle-associated protein	IPI00205056.1	5	
Coro1a Coronin-1A	IPI00210071.3	13	†
Crmp1 Crmp1 protein	IPI00312527.4, IPI00561065.2	8	
CSNK2A1 Casein kinase 2 alpha 1 polypeptide	IPI00016613.2, IPI00120162.1, IPI00192586.1, IPI00408176.2, IPI00744507.1	14	††
Ctnnd2 Isoform 1 of Catenin delta-2	IPI00136135.1, IPI00228632.1, IPI00553941.3	5	††
Cyfip2 Cytoplasmic FMR1-interacting protein 2	IPI00405625.9, IPI00719600.4, IPI00763802.1, IPI00769269.1, IPI00789699.2	10	
Dclk1 Isoform 1 of Serine/threonine-protein kinase DCLK1	IPI00468380.4, IPI00778626.1	8	
Dctn1 Dynactin subunit 1	IPI00196703.1	8	
Dpysl3 Dihydropyrimidinase-related protein 3	IPI00029111.2, IPI00122349.1, IPI00203250.1, IPI00556970.1	7	
Dpysl4 Similar to Dihydropyrimidinase-related protein 4	IPI00366087.1, IPI00558008.1, IPI00779982.1	9	
Dpysl5 Dihydropyrimidinase-related protein 5	IPI00331981.7	6	
Erc1;LOC100048600 Isoform 1 of ELKS/RAB6-interacting/CAST family member 1	IPI00117731.1, IPI00117733.1, IPI00171230.5, IPI00181684.4, IPI00201791.3, IPI00216719.1, IPI00331792.4, IPI00374976.1, IPI00457547.1, IPI00557326.1, IPI00558224.1	8	
Gdi1 Rab GDP dissociation inhibitor alpha	IPI00324986.1	52	
GIT1 Isoform 1 of ARF GTPase-activating protein GIT1	IPI00384861.3, IPI00470095.1, IPI00649373.1, IPI00795611.1	4	
Gnaq Guanine nucleotide binding protein alpha q polypeptide	IPI00228618.5,IPI00230868.4	4	
GNB1 Guanine nucleotide-binding protein G(I)/G(S)/G(T) subunit beta 1	IPI00026268.3, IPI00120716.3	3	
Gnb2l1 Guanine nucleotide-binding protein subunit beta 2-like 1	IPI00317740.5, IPI00641950.3, IPI00848226.1	5	
Homer1 Isoform 1 of Homer protein homolog 1	IPI00210570.1	6	
Jup Junction plakoglobin	IPI00229475.1, IPI00554711.2,	4	†

	IPI00789324.1		
LOC315676 Similar to Dmx-like 2	IPI00369671.3	9	
LOC681252 Similar to Myristoylated alanine-rich C-kinase substrate	IPI00371946.3, IPI00480687.2	4	
LOC685144;LOC681927 Similar to SEC24 related gene family, member C isoform 3	IPI00365299.2, IPI00388782.2, IPI00763148.1, IPI00767454.1, IPI00769013.1	4	†
Ncdn NORBIN	IPI00205396.1, IPI00331299.9, IPI00549543.1, IPI00555661.1	11	
NSF Vesicle-fusing ATPase	IPI00006451.6, IPI00210635.2, IPI00656325.2	10	
Ogt UDP-N-acetylglucosamine - peptide N-acetylglucosaminyltransferase 110 kDa subunit	IPI00231503.4, IPI00420870.4, IPI00845528.1	10	††
Pacsin1 Protein kinase C and casein kinase substrate in neurons protein 1	IPI00208245.1	7	
Pclo Isoform 1 of Protein piccolo	IPI00203018.1, IPI00231831.1, IPI00758462.1	37	††
Picalm Isoform 2 of Phosphatidylinositol-binding clathrin assembly protein	IPI00194959.5	19	††
Plcb1 1-phosphatidylinositol-4,5-bisphosphate phosphodiesterase beta 1	IPI00192534.1, IPI00468121.1, IPI00558422.1	3	
Ppp1r12a Isoform 1 of Protein phosphatase 1 regulatory subunit 12A	IPI00183002.6, IPI00211695.1, IPI00397730.3, IPI00400680.1, IPI00400681.1, IPI00413191.2, IPI00779684.1	21	
Ppp3ca Isoform 1 of Serine/threonine-protein phosphatase 2B catalytic subunit alpha isoform	IPI00121545.1, IPI00179415.4, IPI00201410.1, IPI00559849.1, IPI00747748.1, IPI00756703.1	17	
Prkacb Isoform 1 of cAMP-dependent protein kinase beta-catalytic subunit	IPI00263822.7, IPI00560492.1, IPI00742329.1, IPI00742400.1, IPI00742438.1	3	
Prkwnk1 Serine/threonine-protein kinase WNK1	IPI00200557.1, IPI00561348.1	8	††
Ptpn23 Protein tyrosine phosphatase non-receptor type 23	IPI00782007.1	23	
Rap1gds1_predicted Similar to RAP1, GTP-GDP dissociation stimulator 1	IPI00369496.3, IPI00763518.1, IPI00777342.1, IPI00778032.1	8	
Rapgef2_predicted Similar to Rap guanine nucleotide exchange factor 2	IPI00368346.3	7	
RGD1562629_predicted Similar to Protein neurobeachin	IPI00567941.2	5	
RGD1563580_predicted Similar to AP2 associated kinase 1	IPI00556943.2, IPI00559288.2, IPI00786812.1	8	
Rims1 Isoform 1 of Regulating synaptic membrane exocytosis protein 1	IPI00200893.1, IPI00206312.1, IPI00568548.2, IPI00780218.1	3	
Rph3a Rabphilin-3A	IPI00189927.1, IPI00389991.3	3	
Sec23ip Similar to Sec23 interacting protein	IPI00359906.2	7	
Sec31l1 Isoform 1 of Protein transport protein Sec31A	IPI00210147.2, IPI00515833.1	15	
Shank2 Isoform 2 of SH3 and multiple ankyrin repeat domains protein 2	IPI00231759.3, IPI00231761.1, IPI00400661.2, IPI00470293.3, IPI00475709.1	17	††
SNAP91 Isoform 1 of Clathrin coat assembly protein AP180	IPI00006612.2, IPI00122409.1, IPI00215134.1, IPI00230165.1, IPI00408269.4, IPI00646376.2, IPI00652215.1, IPI00653617.1	41	††
Syn1 Isoform IA of Synapsin-1	IPI00191335.1	4	††
Synj1 Similar to Synaptojanin-1	IPI00210153.3, IPI00229626.7, IPI00231602.2, IPI00850983.1	12	
Ywhab Isoform Long of 14-3-3 protein beta/alpha	IPI00230837.5, IPI00760126.1	4	
YWHAE 14-3-3 protein epsilon	IPI00000816.1	6	
YWHAG 14-3-3 protein gamma	IPI00220642.7	5	
Ywhaq Isoform 1 of 14-3-3 protein theta	IPI00408378.4, IPI00656269.1	7	†
Intracellular Transport			
ATP2A2 Isoform SERCA2A of Sarcoplasmic/endoplasmic reticulum calcium ATPase 2	IPI00468900.4	9	
ATP6V0A1 Isoform 1 of Vacuolar proton translocating ATPase 116 kDa subunit A isoform 1	IPI00465178.5, IPI00743576.1, IPI00796045.1	15	†
ATP6V1A Vacuolar ATP synthase catalytic subunit A	IPI00007682.2, IPI00373076.1, IPI00407692.3, IPI00844689.1	32	
Atp6v1b2 Vacuolar ATP synthase subunit B brain isoform	IPI00119113.3, IPI00199305.1	39	
Dnm1l Isoform 4 of Dynamin-1-like protein	IPI00193568.3, IPI00208284.3	9	
Gorasp2 Golgi reassembly stacking protein 2	IPI00362488.1	7	††
NAPA Alpha-soluble NSF attachment protein	IPI00009253.2, IPI00189925.1	4	

Nup153 Similar to Nuclear pore complex protein Nup153	IPI00480641.3, IPI00768316.1	5	††
Pacs1 Isoform PACS-1a of Phosphofurin acidic cluster sorting protein 1	IPI00324270.4	4	
SEPT5 Septin-5	IPI00017731.1, IPI00559449.2, IPI00655290.2	4	
Sept6_predicted 49 kDa protein	IPI00363930.4, IPI00420385.4, IPI00454142.5, IPI00454143.3, IPI00780333.1	3	
SEPT7 Isoform 1 of Septin-7	IPI00033025.8, IPI00204899.2, IPI00224626.3, IPI00816201.1	3	
Sept11 Isoform 3 of Septin-11	IPI00420385.4, IPI00454142.5	19	
Slc25a12 Calcium-binding mitochondrial carrier protein Aralar1	IPI00308162.3	15	
Slc25a4 ADP/ATP translocase 1	IPI00115564.5, IPI00231927.11, IPI00676622.1	4	
SLC25A5 ADP/ATP translocase 2	IPI00007188.5, IPI00127841.3, IPI00200466.3, IPI00363182.2, IPI00558425.2, IPI00565507.2	3	
Srprb Signal recognition particle receptor B subunit	IPI00196656.2, IPI00476177.2, IPI00679202.2	6	
VCP Transitional endoplasmic reticulum ATPase	IPI00022774.3, IPI00622235.5, IPI00676914.1	12	†
Vdac2 Voltage-dependent anion-selective channel protein 2	IPI00122547.1, IPI00198327.2	5	
Metabolism / Biosynthesis			
Acot7 Isoform B of Cytosolic acyl coenzyme A thioester hydrolase	IPI00125939.2, IPI00213571.1, IPI00230588.1, IPI00284094.4, IPI00326904.5, IPI00566122.1, IPI00672508.1	3	
Aldoal1 Fructose-bisphosphate aldolase	IPI00195851.1, IPI00221402.7, IPI00231734.5, IPI00465439.5, IPI00796333.1	4	
Aldoc Fructose-bisphosphate aldolase C	IPI00231736.9	15	
Atp5a1 ATP synthase subunit alpha, mitochondrial precursor	IPI00396910.1	11	†
ATP5B ATP synthase subunit beta, mitochondrial precursor	IPI00303476.1, IPI00551812.1	13	
Ctbp1 Isoform 1 of C-terminal-binding protein 1	IPI00128155.2, IPI00392657.1, IPI00754844.1, IPI00780254.1, IPI00845557.1	34	
Dlat Dihydrolipoyllysine-residue acetyltransferase component of pyruvate dehydrogenase complex, mitochondrial precursor	IPI00231714.3, IPI00765153.1	3	
Eno1 Alpha-enolase	IPI00462072.3, IPI00464815.11	40	†
Eno2 Gamma-enolase	IPI00326412.4	7	†
Fasn Fatty acid synthase	IPI00200661.1	4	†
Gda Guanine deaminase	IPI00325884.5, IPI00851130.1	16	
Glud1 Glutamate dehydrogenase 1, mitochondrial precursor	IPI00016801.1, IPI00027146.1, IPI00114209.1, IPI00324633.2, IPI00753095.1	8	
Glul Glutamine synthetase	IPI00324020.6, IPI00626790.2	10	
Got1 Aspartate aminotransferase, cytoplasmic	IPI00421513.8	11	
Got2 Aspartate aminotransferase, mitochondrial precursor	IPI00210920.1	17	
Gpi Glucose-6-phosphate isomerase	IPI00364311.1	3	
Hk1 Hexokinase-1	IPI00202543.1	22	
Hmgcs1 Hydroxymethylglutaryl-CoA synthase, cytoplasmic	IPI00188158.1	4	
IDH3A Isoform 1 of Isocitrate dehydrogenase [NAD] subunit alpha, mitochondrial precursor	IPI00030702.1, IPI00198720.1, IPI00459725.2	3	†
LOC316632 NADH dehydrogenase 1 alpha subcomplex 10-like protein	IPI00189759.1, IPI00561513.1	3	
LOC360975 2-oxoglutarate dehydrogenase E1 component, mitochondrial precursor	IPI00215093.1, IPI00390995.2, IPI00782594.1	3	
Ndufs1 NADH-ubiquinone oxidoreductase 75 kDa subunit, mitochondrial precursor	IPI00358033.1	56	
Ndufs2 NADH dehydrogenase [ubiquinone] iron-sulfur protein 2, mitochondrial precursor	IPI00128023.3, IPI00471647.1, IPI00830766.1	3	
Oxr1 Similar to Oxidation resistance 1	IPI00199013.7, IPI00764149.1	3	
Pdha1 Pyruvate dehydrogenase E1 component alpha subunit somatic form, mitochondrial precursor	IPI00191707.4, IPI00337893.2, IPI00393034.3, IPI00764176.1, IPI00768086.2	3	
Pdhb Pyruvate dehydrogenase E1 component subunit beta, mitochondrial precursor	IPI00194324.2	7	
Pfkm 6-phosphofructokinase muscle type	IPI00331541.5	12	
Pfkp 6-phosphofructokinase type C	IPI00231954.5	4	

Pgam1 Phosphoglycerate mutase 1	IPI00421428.9, IPI00453476.2, IPI00457898.3, IPI00549725.6, IPI00740800.1	9	†
Pgk1 Phosphoglycerate kinase 1	IPI00231426.6, IPI00372910.2, IPI00555069.3	9	†
Phgdh D-3-phosphoglycerate dehydrogenase	IPI00225961.5, IPI00475835.3	3	†
Pkm2 Isoform M1 of Pyruvate kinase isozymes M1/M2	IPI00231929.6	11	†
Psat1 Phosphoserine aminotransferase	IPI00331919.5	6	
Pygb Glycogen phosphorylase brain form	IPI00229796.3, IPI00357945.1	6	
Taldo1 Transaldolase	IPI00124692.1, IPI00190377.2	3	
Tpi1 Triosephosphate isomerase	IPI00231767.5,IPI00339162.1	7	†
Tst Thiosulfate sulfurtransferase	IPI00366293.3, IPI00566218.1	3	
mRNA / Protein Processing			
Carm1 Isoform 1 of Histone-arginine methyltransferase CARM1	IPI00125950.2, IPI00279931.1, IPI00366497.3, IPI00412880.2, IPI00568674.2, IPI00639957.2, IPI00650083.2, IPI00655258.2, IPI00830611.1	5	
Cct2 T-complex protein 1 subunit beta	IPI00366218.3	3	
Cct8_predicted Similar to T-complex protein 1 subunit theta	IPI00370815.3	28	†
Fbxo2 F-box only protein 2	IPI00153176.2, IPI00209303.1	3	
Fkbp4 Similar to FK506-binding protein 4	IPI00358443.3, IPI00767393.1	3	
HNRPA1 Isoform A1-B of Heterogeneous nuclear ribonucleoprotein A1	IPI00215965.2, IPI00224251.5, IPI00465365.4, IPI00553777.2, IPI00748262.1, IPI00797148.1	9	†
Hnrpa2b1_predicted Heterogeneous nuclear ribonucleoproteins A2/B1	IPI00212969.2, IPI00358211.3, IPI00396378.3, IPI00405058.6, IPI00414696.1, IPI00622847.2, IPI00828488.1, IPI00853914.1	7	†
Hnrpa3 Isoform 1 of Heterogeneous nuclear ribonucleoprotein A3	IPI00269661.1, IPI00269662.1, IPI00419373.1, IPI00455134.1, IPI00459722.2, IPI00461800.1, IPI00466185.3, IPI00470076.5, IPI00623731.1, IPI00660502.1, IPI00664047.1, IPI00664791.1	12	†
Hnrpc Heterogeneous nuclear ribonucleoprotein C	IPI00130343.2, IPI00187860.3, IPI00216592.2, IPI00223443.1, IPI00223444.1, IPI00477313.3, IPI00759596.1, IPI00759870.1, IPI00759886.1, IPI00781839.1	4	
Hnrpk Hnrpk protein	IPI00194974.2, IPI00216049.1, IPI00216746.1, IPI00223253.1, IPI00224575.1, IPI00514561.1, IPI00777007.1, IPI00780608.1, IPI00807545.1	37	†
Hnrpul2 Heterogeneous nuclear ribonucleoprotein U-like protein 2	IPI00222208.2, IPI00360386.3, IPI00561756.2, IPI00565127.2, IPI00756515.1, IPI00849047.1	4	
Hsp110 Isoform HSP105-alpha of Heat shock protein 105 kDa	IPI00123802.5, IPI00224109.2, IPI00471835.1, IPI00568014.2, IPI00778569.1, IPI00779326.1, IPI00830204.1	3	
Hspa12a_predicted Similar to Heat shock protein 12A	IPI00358537.2	6	
Hspa4 Heat shock 70 kDa protein 4	IPI00387868.2	10	††
Hspd1 Isoform 1 of 60 kDa heat shock protein, mitochondrial precursor	IPI00308885.6, IPI00339148.2, IPI00472102.3, IPI00763910.1, IPI00784154.1, IPI00790763.1	36	††
Hsph1 Heat shock protein 105 kDa	IPI00218993.1, IPI00471835.1, IPI00513743.1, IPI00514983.3	8	
Huwe1 HECT, UBA and WWE domain containing 1	IPI00463909.3, IPI00655012.2	37	
NPEPPS Puromycin-sensitive aminopeptidase	IPI00026216.4, IPI00130000.1, IPI00372700.1, IPI00608097.1, IPI00767572.1, IPI00768609.1	8	†
Otub1;LOC100046081 Ubiquitin thioesterase OTUB1	IPI00154004.1, IPI00371462.3, IPI00755837.1	4	
PABPC1 Isoform 1 of Polyadenylate-binding protein 1	IPI00008524.1, IPI00124287.1, IPI00189074.3, IPI00331552.4, IPI00410017.1, IPI00478522.1, IPI00796945.1	6	†
PCBP2 Poly(rC)-binding protein 2 isoform b	IPI00012066.2, IPI00127707.1, IPI00216689.2, IPI00221796.1, IPI00221799.1, IPI00470509.2,	4	†

	IPI00796337.1		
Pdia3 Protein disulfide-isomerase A3 precursor	IPI00324741.2	9	
Rbm12 Swan	IPI00421433.1, IPI00560597.1	12	
Rbmx Heterogeneous nuclear ribonucleoprotein G	IPI00124979.2, IPI00304692.1, IPI00370207.3, IPI00474144.1, IPI00559910.1, IPI00604873.2, IPI00663587.1, IPI00763272.1, IPI00766882.1, IPI00775821.1, IPI00775899.1	6	
Sf3a1_predicted Similar to Splicing factor 3 subunit 1	IPI00215030.1, IPI00408796.3	5	
SFPQ Isoform Long of Splicing factor, proline- and glutamine-rich	IPI00010740.1, IPI00129430.1, IPI00627068.1, IPI00752791.1, IPI00755611.1, IPI00767277.1, IPI00849080.1	3	†
Thop1 Thimet oligopeptidase 1	IPI00564198.2	4	
Ubqln2_predicted Similar to ubiquilin 2	IPI00362791.3	66	
Uqcrc1 Ubiquinol-cytochrome-c reductase complex core protein 1, mitochondrial precursor	IPI00471577.1	6	
Uqcrc2 Ubiquinol-cytochrome-c reductase complex core protein 2, mitochondrial precursor	IPI00188924.4	3	
USP5 Isoform Long of Ubiquitin carboxyl-terminal hydrolase 5	IPI00024664.1, IPI00207657.1, IPI00375145.1, IPI00767186.1, IPI00768802.1	4	
Transcription / Translation			
Hcfc1_predicted Similar to Host cell factor C1	IPI00367724.3, IPI00765252.1	13	††
CAND1 Isoform 1 of Cullin-associated NEDD8-dissociated protein 1	IPI00100160.3, IPI00205466.1, IPI00420562.5, IPI00746694.1, IPI00753059.1	3	
CNOT1 CCR4-NOT transcription complex subunit 1 isoform A	IPI00166010.6, IPI00359049.4, IPI00673465.1, IPI00674283.1, IPI00752506.1, IPI00757812.1	17	††
DDX17 DEAD box polypeptide 17 isoform 1	IPI00023785.6, IPI00396797.2, IPI00651653.1, IPI00651677.1, IPI00653307.1	4	
DDX5 Probable ATP-dependent RNA helicase DDX5	IPI00017617.1, IPI00420363.2, IPI00464718.1	3	
Eef1a1 Elongation factor 1-alpha 1	IPI00195372.1, IPI00307837.5, IPI00396485.3, IPI00472724.1, IPI00551729.1	5	†
EEF2 Elongation factor 2	IPI00186290.6, IPI00203214.6, IPI00466069.3, IPI00849291.1	4	††
EG268795 Similar to 60S ribosomal protein L7a (Surfeit locus protein 3) isoform 1	IPI00265107.4, IPI00299573.12, IPI00330363.8, IPI00354363.3, IPI00397676.4, IPI00462006.3, IPI00462453.4, IPI00478896.2, IPI00479315.2, IPI00622160.3	3	
Eif4a2 Eukaryotic initiation factor 4A-II	IPI00193595.3, IPI00328328.3, IPI00400432.2, IPI00409717.1, IPI00409918.1	3	
Eif4g3_predicted Similar to Eukaryotic translation initiation factor 4 gamma 3	IPI00365284.3, IPI00767350.1	6	
pur-beta Transcriptional activator protein Pur-beta	IPI00189358.2	3	
RGD1560833_predicted Similar to MKL/myocardin-like 2	IPI00765655.1	2	
Ripx Protein RUFY3	IPI00204065.1, IPI00206350.3	3	
RPS3 40S ribosomal protein S3	IPI00011253.3, IPI00134599.1, IPI00212776.1	4	†
RPS8 40S ribosomal protein S8	IPI00216587.9, IPI00231202.6, IPI00274175.1, IPI00466820.4, IPI00475203.1, IPI00621229.1, IPI00645201.1, IPI00671398.1, IPI00756488.1, IPI00756959.1, IPI00828628.1, IPI00849948.1	3	†
Vezf1_predicted 22 kDa protein	IPI00780927.1	4	
Zfr Similar to Zinc finger RNA binding protein	IPI00367952.3, IPI00765814.1	8	††
Uncharacterized			
Hnrpul2 Heterogeneous nuclear ribonucleoprotein U-like protein 2	IPI00222208.2, IPI00360386.3, IPI00561756.2, IPI00565127.2, IPI00756515.1, IPI00849047.1	4	

Immt 82 kDa protein	IPI00364895.4, IPI00566985.1, IPI00777695.1	8	
LOC314432 Similar to Ubiquitin-protein ligase (EC 6.3.2.19) E1-mouse	IPI00368347.2	7	
LOC501546 LOC501546 protein	IPI00201213.3	3	
MGC93707 Mitochondrial antiviral-signaling protein	IPI00364200.1	3	
RGD1562348_predicted Similar to Ankyrin repeat domain protein 17 isoform B	IPI00361795.2, IPI00388314.3	9	
RGD1563977_predicted Similar to Protein 4.1G	IPI00191995.2, IPI00192909.2, IPI00368431.2, IPI00388101.1, IPI00393242.1	3	
RGD1566064_predicted Similar to HBxAg transactivated protein	IPI00363856.3	13	
SH3GLB2 Isoform 1 of SH3 domain GRB2-like protein B2	IPI00024540.3, IPI00153832.1, IPI00398828.1, IPI00626834.2, IPI00756786.1, IPI00776533.1, IPI00779094.1, IPI00828453.1	16	
Ubap2_predicted Similar to Ubiquitin-associated protein 2	IPI00190431.4	13	
Ubap2l Isoform 5 of Ubiquitin-associated protein 2-like	IPI00407835.1, IPI00412535.2, IPI00514856.4, IPI00761937.1	6	

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